Spire CSDAP Data FAQ

What types of data do Spire satellites collect and are being made available in the CSDAP holdings?

Spire satellites primarily collect data using a science-grade, dual-frequency GNSS receiver. The Spire GNSS receiver collects primarily both rising and setting radio occultation observations using fore and aft facing "RO" antennas. A third dual-frequency zenith antenna collects observations for precise orbit determination (POD). Typical RO data products include:

- *Low-level 50 Hz data (opnGns format)*
- *Excess phase (atmPhs)*
- *Atmospheric profile (atmPrf and bfrPrf)*
- *Slant TEC (podTEC)*
- *Ionospheric density profile (ionPrf)*
- *Precise orbit determination (leoOrb)*
- *Scintillation indices (scnLv1)*

Grazing angle GNSS reflections from the Earth surface are also observed in the fore and aft RO antennas to perform a new type of GNSS-R. These observations include both the direct and reflected signals and allow precise altimetry under conditions of coherent reflections. These data are derivations of and similar to traditional 50 Hz RO data.

A limited number of low-level, raw intermediate frequency (IF) data collected by both RO satellites (for grazing angle reflections) and GNSS-R satellites are also available.

Each Spire satellite also collects attitude (leoAtt) and raw magnetometer data from the attitude determination and control system (ADCS).

As new data types are created by Spire, such as from the recent launch in Dec. 2019, of two GNSS-R specific satellites, these data will undergo evaluation by NASA prior to their inclusion into the CSDAP holdings.

What is the time period of the data provided to the CSDAP?

Spire is supplying data from Nov. 1, 2019 through April 30, 2021. Not all data types are available at earlier dates.

What are the characteristics of the Spire constellation?

Spire launches 3U CubeSats into a variety of orbits, including sun synchronous polar orbits with varying local time sampling and orbits of various inclinations (e.g., 83 deg, 51.6 deg (ISS), 37

deg). Orbit altitudes range from approximately 450 to 600 km. At any given time, many satellites are producing data, and the satellites which are used in production vary over the period of the CSDAP holdings. Currently, the constellation produces about 7000-9000 RO profiles and 1000-2000 grazing angle reflection arcs (an arc is about 3 to 5 min in length) each day using only a subset of the available satellites (actual capacity is much greater), with the expectation that these values will scale with new launches.

Do the satellites and/or payloads change significantly over time?

Over the period of the CSDAP holdings, the Spire satellites and payloads did not change significantly except for the addition of a larger solar array and a second RO antenna (early satellites had only one RO antenna). A list of bus and payload changes is available.

What is the geographic and temporal distribution of Spire data?

Due to the variety of orbits, Spire data sample the entire Earth. Temporal sampling is also varied, but local times do preference some sun synchronous orbits.

What GNSS signals are used in RO and GNSS-R observations?

The current Spire GNSS receiver (STRATOS v1) produces RO using GPS, Galileo, GLONASS, and QZSS signals. Grazing angle reflections are currently produced using GPS signals but will in the future use other GNSS signals, as RO currently does. Raw IF data contain all signals observed by the antennas.

What applications can be addressed or studied with Spire data?

POD GNSS navigation data (e.g., RINEX or leoOrb):

- *Estimation of LEO satellite drag and derivation of thermospheric density*
- *High-low ranging for satellite gravity and reference frame studies*

RO data:

- *Atmospheric soundings*
- *Data assimilation*
- *Ionospheric anomalies*
- *Space weather monitoring*

Grazing angle GNSS-R

- *Sea surface altimetry (where coherent)*
- *Sea ice classification and altimetry*